Research title:	**Nozzle Testing Chamber**
Researcher:	**Emre Mengi**
Week period:	**August 5, 2019 (Mon) – August 9, 2019 (Fri)**
Meeting time:	**August 5, 2019 (Mon)**
Created date:	**August 4, 2019 (Sun)**
Term:	**Summer 2019**

1. Summary of last discussions

- Improve the glass plate support (possibly by adding L-channels on both sides of glass which then is attached to the side extrusion with bolt adjustments)
- Look into the camera mount (possibly use an extra threaded plate to ensure the camera is rigid)
- Look into a level device to keep the camera level
- Get/design a lens shroud to prevent glare
- Keep in mind nozzle direction for different setups
- Plan B for vent (Do calculations on powder jump w.r.t. particle size and height, 50µm to 110 µm, assume 30m/s flow into the chamber

2. Summary of progress

- Revised the design as discussed in the last meeting:
  - Referring to the Appendix A:
    - A: Added two more legs to accommodate a desk extension without cantilever. New design has more desk space and the camera mount is over the desk space where the desk acts as a safety precaution in case the mount fails.
    - B: The camera mount now features an aluminum plate with slots that allow for camera orientation calibration and ensures the camera is rigid.
    - C: Target surface mount design is now revised. Instead of the T-slot extrusions and respective pivots, square tubing is used to hold the glass on both sides, which in turn is secured onto an aluminum plate that can be moved up and down through the vertical t-slot member.
  - Referring to the Appendix B:
    - Done hand calculations on powder jump w. r. t. particle size and height, where it showed that no metal particles can ricochet and reach the top of the enclosure at any speed. Calculated the net force on a supposedly suspended particle at the vent outlet experiencing an argon flow upwards.

Calculations showed that the particle will fall instead of going out of the vent even at flow rate of 30 L/min.

3. Goals for next week

- Finalize the design

Appendices

Appendix A

Screenshots of the current SOLIDWORKS model of the nozzle testing chamber:

Isometric View 1:

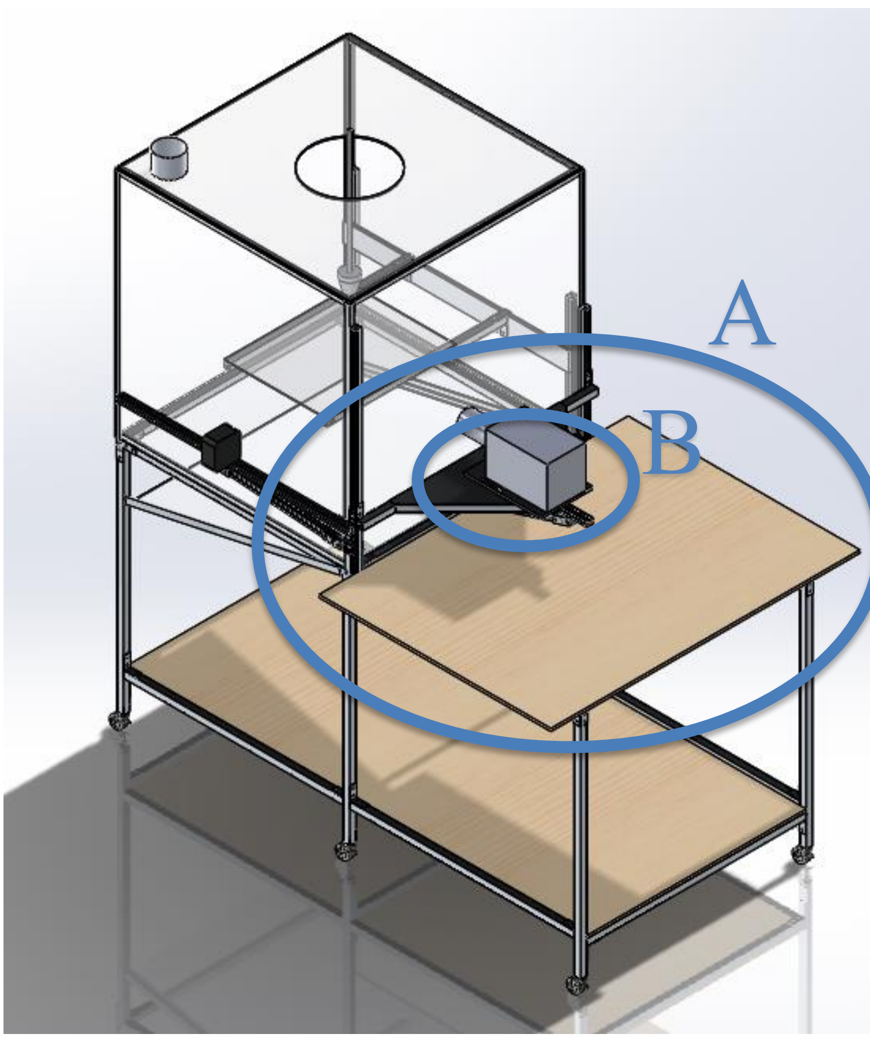

Figure 1. *Isometric view of the revised chamber design.*

A:

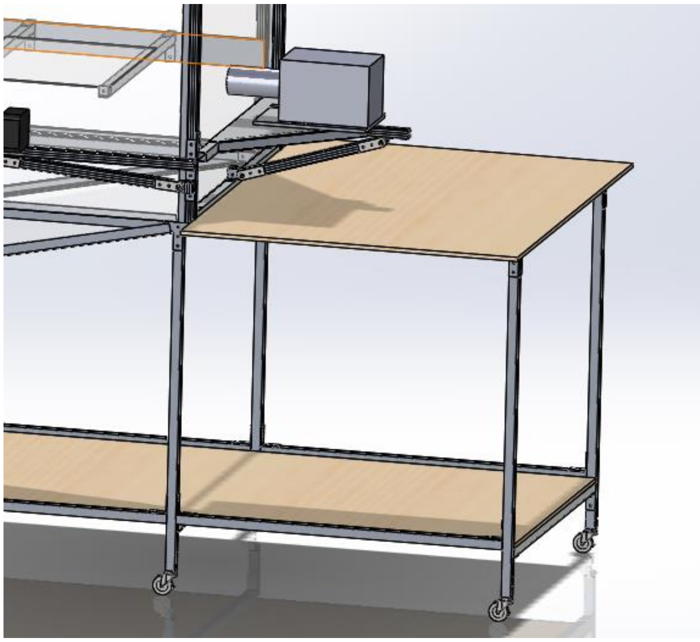

Figure 2. *Close-up of the extended desk space and bottom panel.*

B:

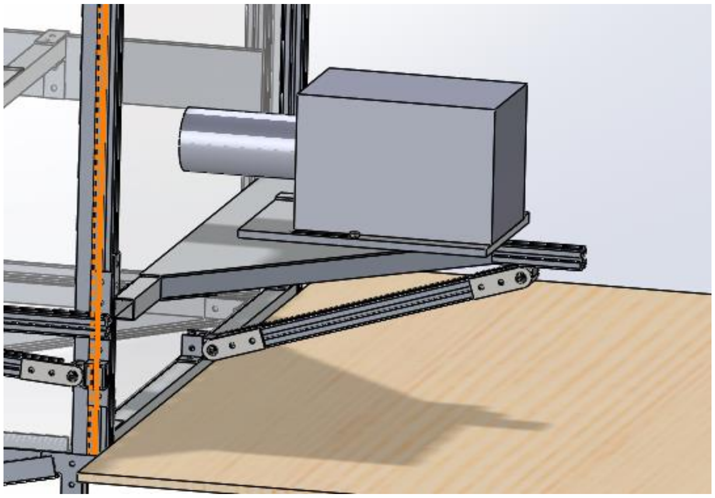

Figure 3. *Close-up of the camera mount.*

Isometric View 2:

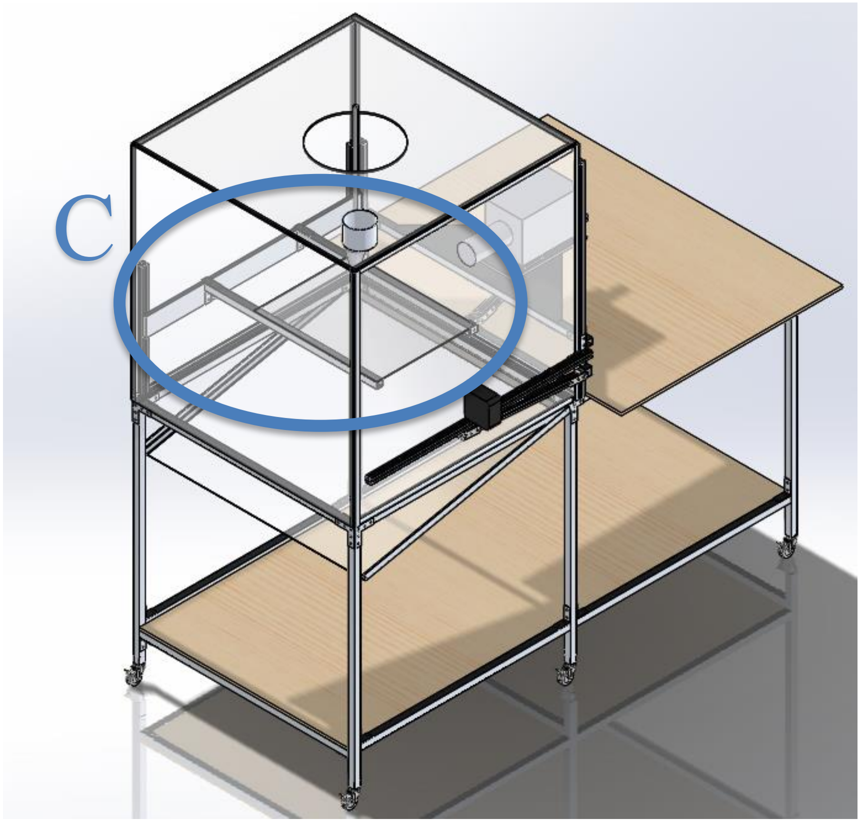

Figure 4. Another i*sometric view of the revised chamber design.*

C:

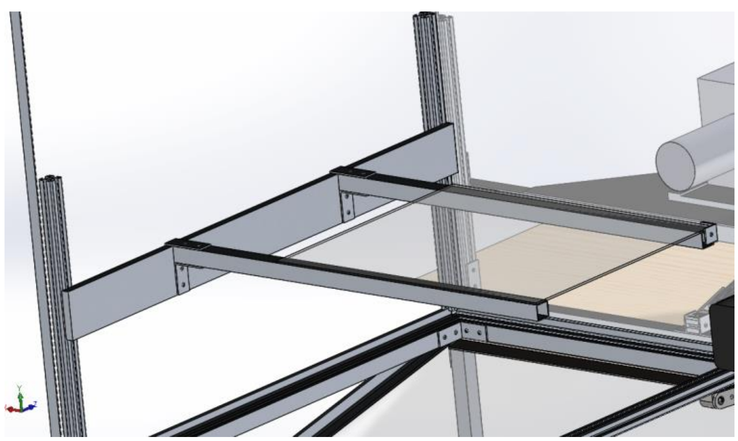

Figure 5. *Close-up of the revised target surface mount.*

Appendix B

1. For the powder jump calculation, a single particle is considered to be entering the chamber that has air in the medium with the following constants:

Table 1. *Constants for the particle and air at 20°C.*

Constants	
Temperature [°C]	20
Air density [kg/m3]	1.2
Dynamic viscosity of Air [N*s/m2]	1.80E-05
Diameter of Sphere [m]	5.00E-05
Unit Weight of SS [N/m3]	76000
Frontal Area of Sphere [m2]	3.93E-09
Velocity of Sphere [m/s]	30
Reynolds Number	1.00E+02
Drag Coefficient for Sphere (From NASA charts)	1.1
https://www.grc.nasa.gov/WWW/K-12/airplane/dragsphere.html	

For a single particle that is enters the chamber through the nozzle outlet at different speeds, the final velocity due to drag force is plotted below:

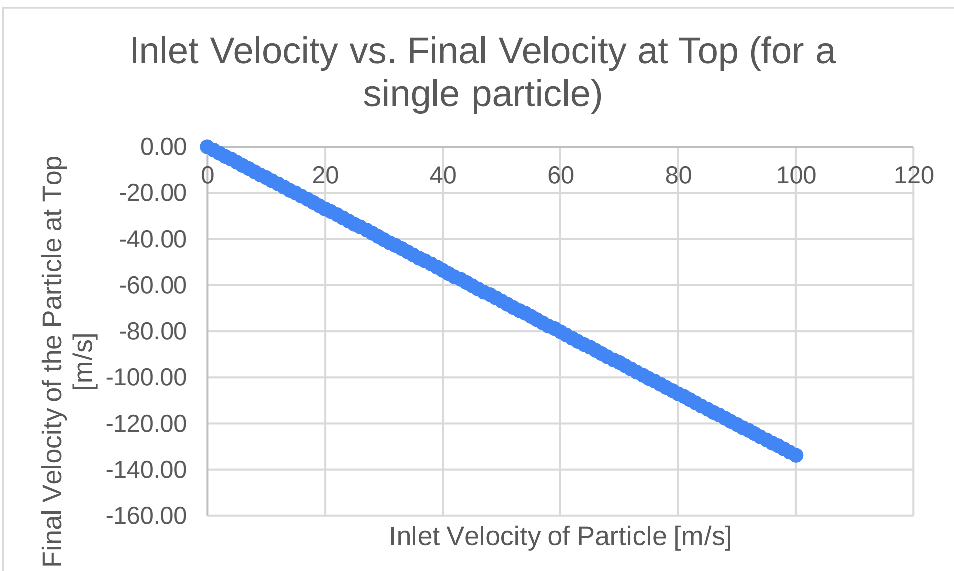

Figure 6. *Inlet Velocity vs. Final Velocity at Top (for a single particle)*

Negative values for final velocity indicate that the final momentum of the particle goes to zero before it reaches the top of the enclosure after an elastic collision with the glass target surface due to drag force.

2. For the argon exit flow calculation, a particle is assumed to be suspended at the vent outlet: the net force on the particle is calculated to show that any particle will drop down to the enclosure instead of being pushed up by the argon flow.

The constants for this calculation are:

Table 2. *Constants for the particle and argon at 20°C.*

Constants	
Temperature [°C]	20
Argon density [kg/m3]	1.662417
Dynamic viscosity of Argon [N*s/m2]	2.24E-05
Diameter of sphere [m]	5.00E-05
Unit Weight of SS [N/m3]	76000
Flow Rate of Argon [m3/s]	0.0005
Frontal Area of Sphere [m2]	3.93E-09
Outlet Cross-Sectional Area [m2]	2.03E-03
Velocity of Argon Flow [m/s]	2.47E-01
Reynolds Number	1.86E+03
Drag Coefficient for Sphere (From NASA charts)	0.3
https://www.grc.nasa.gov/WWW/K-12/airplane/dragsphere.html	

The calculated results are:

Table 3. *Net force acting on the particle.*

Drag Force [N]	5.96E-11
Mass of a particle [kg]	5.07E-10
Weight of a particle [N]	4.97E-09
Net Force (- indicates going down)	-4.91E-09

The net force acting on the particle is negative, meaning that the particle will fall into the enclosure even at the vent outlet.

References

Budynas, Richard G., et al. *Shigley's Mechanical Engineering Design*. McGraw-Hill Education, 2015.

White, Frank M. *Fluid Mechanics.* McGraw-Hill Education, 2016.

"Drag of a Sphere." *NASA*, NASA, www.grc.nasa.gov/WWW/K-12/airplane/dragsphere.html. Accessed on 8/9/2019.